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Helium Resources of the United States, 1979

By B. J. Moore



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By B. J. Moore



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HELIUM RESOURCES OF THE UNITED STATES, 1979

by

B. J. Moore¹

ABSTRACT

The Bureau of Mines has estimated helium resources of the United States at 727 billion cubic feet as of January 1, 1979. These resources are divided into four categories in decreasing degrees of assurance of their existence: (1) Helium in storage and in measured natural gas reserves, 185 billion cubic feet; (2) helium in indicated natural gas resources, 150 billion cubic feet; (3) helium in hypothetical natural gas resources, 186 billion cubic feet; and (4) helium in speculative natural gas resources that makes up the remaining 206 billion cubic feet.

The identified helium reserves, which are made up of that in measured and indicated natural gas categories, are further divided into depleting, non-depleting, and stored classifications. The depleting resources are those that are associated with natural gasfields that are, or will be, produced for the natural gas they contain. All of the helium in undiscovered natural gas resources are included in this classification. These depleting resources comprise 600 billion cubic feet of the total resource base. The nondepleting helium resources are estimated to total 88 billion cubic feet. There is 39 billion cubic feet of helium in storage in Cliffside gasfield near Amarillo, Tex.

INTRODUCTION

The helium resource base of the United States was estimated to be 726.8 billion cubic feet as of January 1, 1979. This includes helium contained in natural gas resources, both identified and undiscovered, and helium in storage in Cliffside gasfield that was previously separated from natural gas streams.² This publication is the third in a series of reports on the helium resources of the Nation. The two previous reports gave information on

¹Chief, Unit of Helium Resources Evaluation, Section of Helium Resources, Helium Field Operations, Bureau of Mines, Amarillo, Tex.

²See appendix for definition of terms.

those resources as of January 1, 1973,³ and January 1, 1977.⁴ The Bureau of Mines has been estimating the helium resources of the Nation for over 25 years in connection with a search for helium occurrences that has been conducted for more than 60 years. These activities are carried on (1) to insure a continuing supply of helium to fill essential Federal needs, (2) to provide information to the Secretary of the Interior so as to properly manage the helium resources reserved to the United States on Federal land, and (3) to provide the public with information on a limited natural resource that is being wasted. The Mineral Leasing Act of 1920 reserves to the United States all helium found on lands under Federal oil and gas leases. The responsibility for insuring a supply of helium to meet essential Federal needs was assigned to the Secretary of the Interior by the Helium Act of March 3, 1925. The latest legislation on helium is the Helium Act Amendments of 1960.

The estimate of the total helium resource base of 727 billion cubic feet compares with 710 billion cubic feet estimated as of January 1, 1977. The increase is due principally to an increase in the estimate of undiscovered natural gas resources in the Overthrust belt area of the Rocky Mountain region and as a result of expanding the area of consideration on the Outer Continental Shelf from water depths of 1,500 feet to 3,281 feet due to improved technology in the offshore drilling and producing industry. The increase in estimates of natural gas resources in the Overthrust belt is the result of intense drilling activity in the area recently that has produced several discoveries of significant natural gasfields. These discoveries lead the estimators to believe that there is much more gas in this area than was previously thought.

The helium resources are reported in four categories: (1) Helium in measured natural gas reserves and in storage, (2) helium in indicated natural gas resources, (3) helium in hypothetical natural gas resources, and (4) helium in speculative natural gas resources. Helium in storage is the helium stored by the Department of the Interior in the Cliffside storage field near Amarillo, Tex. Helium in measured reserves is that in the proved natural gas reserves as estimated by the American Gas Association (AGA) and in those non-depleting fields not included in the AGA estimates. The indicated, hypothetical, and speculative natural gas resources are those estimated to exist by the Potential Gas Committee (PGC). Additionally, there is 59.8 billion cubic feet of helium estimated to exist in nondepleting indicated resources not included in the PGC estimates.

Helium in identified resources is sometimes reported by helium content in three groups: 0.3 percent or more, 0.1 to 0.29 percent, and less than 0.1 percent. These ranges have no particular significance, but, in general, the higher the percentage of helium contained in the gas, the more likely the helium could be economically extracted. In earlier years, gas containing at least 0.3 percent helium, or helium-rich gas, was the only gas of concern to the helium evaluation program. Now, because of the wider scope of the present

³Moore, B. J. Helium Resources of the United States, 1973. BuMines IC 8708, 1976, 17 pp.

⁴_____. Helium Resources of the United States, 1977. BuMines IC 8803, 1979, 25 pp.

helium resource survey and because gases containing less helium than 0.3 percent can be economically processed, the terms "0.3 percent helium" and "helium-rich gas" are no longer appropriate. Helium recovery cost is affected by many other variables, including average daily rate of gas processed, hydrocarbon recovery, life of reserves, and total helium reserves.

HELIUM RESOURCES

Helium occurs as a constituent of natural gas, and this is presently the only economical source of helium, although it is also present in much smaller concentrations in the atmosphere. For the purposes of this report, only those helium resources found in natural gas or previously separated from natural gas and now in storage will be considered as a part of this Nation's helium resource base. The natural gas in which the helium is found may be normal fuel gas or naturally occurring gas of low heating value. Figure 1 shows the estimated helium resources of the United States in the various classifications.

IDENTIFIED		UNDISCOVERED	
MEASURED INCLUDING STORED HELIUM (PROVED)	INDICATED (PROBABLE)	HYPOTHETICAL (POSSIBLE)	SPECULATIVE (SPECULATIVE)
185	150	186	206
T O T A L	R E S O U R C E S	7 2 7	

← INCREASING DEGREE OF GEOLOGICAL ASSURANCE →

FIGURE 1. - Helium resources of the United States as of January 1, 1979, by category of resource. Volumes in billions of cubic feet at 14.73 psia and 60° F, industry terminology in parentheses.

Based on past experience, helium appears to be a minor constituent of all natural gas. In the Bureau of Mines files of gas analyses, some of the older analyses of gas samples show no helium present, but it is believed that if those samples had been analyzed with the more precise analytical equipment available today, some helium would have been detected. All samples of recent years have contained at least traces of helium when analyzed on the sensitive helium analytical apparatus. The helium resources shown in figure 1 are contained in both identified and undiscovered natural gas resources. The undiscovered gas resources were estimated in a study made by the PGC, but whether they will be discovered or whether it will be economical to extract helium from them will depend on many factors. Included with these resources are those helium deposits categorized as reserves. Helium reserves are defined as helium in identified gas reserves having at least 0.3 percent helium by volume and at least 100 million cubic feet of recoverable helium.

The resource terms or classifications used throughout this report and shown on figure 1 are defined in the appendix. These terms are somewhat different from terms used by the PGC and other segments of the gas industry. However, the two systems of terminology can be compared, and the corresponding industry terms are shown in parentheses on the figure.

Helium contents of the natural gas resources were derived from the Bureau's records of helium analyses of natural gas samples. The analyses of natural gas and limited evaluations of helium resources were begun in 1917. More than 15,000 natural gas samples from wells and pipelines in the United States have been analyzed. Through 1978, 11,883 of these analyses had been published in 21 Bureau of Mines publications, which are listed in the bibliography of this report.

Helium in Storage

In 1961 the Government contracted to purchase helium from five extraction plants built by four private companies adjacent to large natural gas transmission pipelines. The gas, principally from the West Panhandle and Hugoton gasfields in the Oklahoma and Texas Panhandles and in southwest Kansas, was being produced for fuel, and as the gas was burned, the helium was released to the atmosphere and wasted. Using private funds, companies constructed the plants to extract crude helium for sale to the Government. The helium was delivered into a Government-owned pipeline that connected all plants with the Cliffside helium storage field near Amarillo, Tex. Further information concerning the Government's helium purchases can be found in the first report of this series.⁵

As of January 1, 1979, the helium stored in Cliffside field totaled 39.1 billion cubic feet. This is comprised of 37.1 billion cubic feet of helium that was accepted by the Government from the conservation plants under contract or court order, or was produced by Government-owned helium extraction plants and was excess to Federal market demands. The other 2.0 billion

⁵Work cited in footnote 4.

cubic feet is stored by the Government for private companies under separate contracts. Cliffside field was the source of helium-bearing natural gas which was processed for helium extraction at the Government's Amarillo helium plant from 1929 until the plant ceased operations in April 1970. About 94 billion cubic feet of natural gas has been produced from the field, but there is still about 214 billion cubic feet remaining. The natural gas contains about 1.86 percent helium. Since the closing of the Amarillo helium plant, only minor amounts of natural gas have been produced from the field to facilitate storage and plant operations. Helium contained in the remaining native gas is included with the helium in measured natural gas reserves.

Helium in Measured Reserves of Natural Gas

Helium in measured reserves of natural gas is divided into three groups by helium content: 0.3 percent or more, 0.1 to 0.3 percent, and 0 to 0.1 percent. The limits of these groups have no particular significance. Presently, no helium is being extracted from gas streams with less than 0.3 percent helium. However, once the higher helium content gas is depleted, gas containing at least 0.1 percent helium will be the most attractive for processing. The gas containing the lowest helium percentage will likely to be last to be considered as a possible helium source. Known fields containing at least 0.3 percent helium have been identified and evaluated in the helium resources evaluation program. Fields in the 0.1 to 0.3 percent helium range are now being studied in this program, but work has been completed in only nine of the gas producing States. In other gas producing States, the helium resources in gases with less than 0.3 percent helium cannot be separated into the two lower helium content groups. These resources are simply reported as being in the less than 0.3 percent helium content range. Because the two lower helium content groups are not separated in some areas, the helium resources in all gases with less than 0.3 percent helium are discussed under one section.

Helium in Natural Gas Containing 0.3 Percent or More Helium

As of January 1, 1979, it was estimated that there was 84.0 billion cubic feet of helium contained in the measured natural gas reserves having at least 0.3 percent helium in the United States. These reserves were located in 75 fields in 10 States (table 1).

TABLE 1. - Helium reserves of the United States in measured natural gas reserves containing 0.3 percent or more helium, by State

(Million cubic feet at 14.73 psia and 60° F)

<u>State</u>	<u>Helium</u>
Arizona.....	820
Colorado.....	1,095
Kansas.....	39,249
Montana.....	471
New Mexico.....	624
Oklahoma.....	9,516
Texas.....	21,045
Utah.....	4,298
West Virginia.....	117
Wyoming.....	6,757
Total.....	<u>83,992</u>

Since 1950, the Bureau of Mines has made estimates of the helium resources of the Nation, although for several years the estimates included only the fields that contained major deposits containing at least 0.3 percent helium. These fields were the Hugoton in southwest Kansas and the Oklahoma and Texas Panhandles, West Panhandle in Texas, Greenwood in Kansas, Keyes in Oklahoma, and Cliffside in Texas. Even today these fields are estimated to contain about 77 percent, or 64.6 billion cubic feet of the helium in gas with at least 0.3 percent helium. The natural gas from all these fields, except Cliffside, is being produced for fuel, and the helium that is not extracted is lost with the flue gas as the natural gas is burned.

As the helium resources evaluation program progressed through the years, more comprehensive data were collected and the estimates were improved. In 1961, a major improvement in the program took place when, for the first time, helium reserves were estimated for all fields from which samples containing more than 0.3 percent helium had been analyzed in connection with the gas-sampling program. Available data for many of these smaller fields were limited for the first evaluation efforts, but over the intervening years, data have been collected from all known available sources and this has resulted in a comprehensive assessment of the total helium reserves of the country. The measured helium reserves estimates for each year beginning in 1950 appear in table 2 which also compares the trend of helium reserves of the United States with the natural gas reserves as estimated by the AGA.

TABLE 2. - Helium in estimated measured natural gas reserves containing 0.3 percent or more helium

(Million cubic feet at 14.73 psia and 60° F)

Year	Helium contained in natural gas having at least 0.3 percent helium	Helium in storage	AGA estimates of natural gas reserves ¹
1950.....	248,642	82	179,401,693
1951.....	242,675	81	184,584,745
1952.....	242,675	86	192,758,910
1953.....	235,713	87	198,631,566
1954.....	229,745	86	210,298,763
1955.....	222,783	86	210,560,931
1956.....	216,816	70	222,482,544
1957.....	210,849	46	236,483,215
1958.....	203,887	24	245,230,137
1959.....	197,919	17	252,761,792
1960.....	192,946	106	261,170,431
1961.....	194,373	268	262,326,326
1962.....	194,373	438	266,273,642
1963.....	191,311	509	272,278,858
1964.....	187,855	2,042	276,151,233
1965.....	177,886	5,317	281,251,454
1966.....	169,695	8,870	286,468,923
1967.....	163,589	12,407	289,332,805
1968.....	155,076	16,138	292,907,703
1969.....	148,408	19,863	287,349,852
1970.....	140,386	23,693	275,108,835
1971.....	135,850	27,573	290,746,408
1972.....	127,873	31,491	278,805,618
1973.....	119,515	34,903	266,084,846
1974.....	113,470	37,426	249,950,207
1975.....	108,358	37,501	237,132,497
1976.....	101,152	37,760	228,200,176
1977.....	96,745	38,261	216,026,074
1978.....	89,783	38,651	208,877,878
1979.....	83,991	39,055	200,301,707

¹ AGA reserve estimates are given as of December 31 of previous year.

Prior to the inauguration of crude helium purchases in late 1962, all of the previously mentioned gasfields with large helium reserves, except Cliff-side, were being produced for fuel. The resultant loss of helium amounted to about 8 billion cubic feet per year. Under the crude helium purchase program, about 3.5 billion cubic feet of the helium that would otherwise have been wasted was saved annually from 1963 through November 12, 1973, when acceptance of helium from the conservation plants ceased. In 1978, about 1.5 billion cubic feet of helium was extracted by both Government and private plants and

either used or stored in Cliffside field. During that same year, about 5.5 billion cubic feet of helium in gas containing at least 0.3 percent helium was lost to the atmosphere as the gas was used for fuel.

There are gasfields that contain gas with at least 0.3 percent helium that are not being produced and, consequently, the helium is not being depleted. These are classified as the nondepleting helium reserves and there are 34 fields containing gas in this category. The measured helium reserves of these fields are estimated at 16.5 billion cubic feet. There are various reasons why these fields are not being produced. Some are located in remote areas where pipeline connections are not presently available, and in other cases, the gas is being used in pressure-maintenance operations to produce associated oil. In the majority of instances, however, the helium is in natural gas that has low-heating value and thus is not economically valuable for fuel. The fields in the first two groups will probably be put on production eventually, and the helium reserves will then be removed from the non-depleting category. As natural gas prices rise, some of the fields in the third group, those that were noncommercial at the time of discovery, may become profitable and then be produced.

In the presently classified nondepleting fields, there are estimated to be 16.5 billion cubic feet of measured helium reserves. About 13.3 billion cubic feet of this is contained in natural gas located on Federal lands. The Government retains title to all helium under these Federal lands, thus title to this helium is held by the Government even though the oil and gas rights may be leased to private companies or individuals. These nondepleting reserves on Federal lands may serve as a backup to the helium stored by the Government and are an integral part of the Government's helium conservation efforts.

Helium in Natural Gas Containing Up to 0.3 Percent Helium

The helium resources evaluation program was expanded in 1974 when the first efforts were made to estimate the helium resources of individual gas-fields that produced gas with at least 0.1 percent helium but less than 0.3 percent helium. This expansion came as a result of improved technology and economics of operations made possible by multipurpose plants that make it feasible to process gas with lower helium contents. The evaluation of these fields is done on an area-by-area basis, and eventually the entire United States will be evaluated. As of January 1, 1979, evaluation of the helium in fields with gases having helium contents from 0.1 to 0.3 percent had been completed in Colorado, Kansas, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, Utah, and Wyoming. Work was in progress to evaluate the helium resources of those fields in the Appalachian Region of the north-eastern United States. Colorado, Nebraska, North Dakota, and South Dakota have no significant helium resources in gases with 0.1 to 0.3 percent helium contents.

The resources contained in measured gases with helium contents of 0.1 to 0.3 percent in those other States for which evaluations have been completed are as follows:

<u>State</u>	<u>Million cubic feet¹</u>
Kansas.....	912
Montana.....	314
Oklahoma.....	1,683
Utah.....	32
Wyoming.....	12,137
<u>Total.....</u>	<u>15,078</u>

¹At 14.73 psia and 60° F.

In other States, helium resources in gases with helium contents of 0.1 to 0.3 percent are estimated by using the helium contents of fields from which we have gas samples in conjunction with gases having 0.29 percent helium or less to find an average helium content of a State or subdivision of a State. By applying an average helium content to the estimated gas reserves of an area, less those natural gas reserves contained in fields having at least 0.3 percent helium, an estimate of the helium contained in gases having 0.29 percent helium or less can be made.

Since 1945, the AGA has made annual estimates of the natural gas reserves of the United States. The estimate as of the end of 1978 was used in conjunction with helium contents derived from the gas analysis data from the Bureau's helium analysis files to estimate the volume of helium in the measured reserve of gas having less than 0.3 percent helium. The AGA annual reserve estimates and helium reserve estimates are given in table 2, and trends are shown on figure 2.

The AGA estimate of measured natural gas reserves of the United States as of December 31, 1978,⁶ was 200,302 billion cubic feet. The estimate was made by combining estimates of gas reserves of several geographic divisions within the country. Table 3 shows the gas reserve estimate for each geographical area as published by the AGA.

⁶American Gas Association, Committee on Natural Gas Reserves. Report on Natural Gas Reserves of the United States. Apr. 30, 1979, 7 pp.

TABLE 3. - American Gas Association natural gas proved¹ reserve estimates as of December 31, 1978, with applicable helium content fraction and helium in gas having less than 0.3 percent helium

(Volumes in million cubic feet at 14.73 psia and 60° F)

Area	Natural gas reserves	Helium content fraction	Helium contained in natural gas having less than 0.3 percent helium
Alabama.....	751,219	0.00060	451
Alaska.....	31,612,295	.00014	4,426
Arkansas.....	1,627,064	.00092	1,497
California.....	5,095,082	.00005	255
Colorado.....	1,965,765	.00042	² 554
Florida.....	160,296	.00015	24
Illinois.....	420,437	.00103	433
Indiana.....	56,710	.00135	77
Kansas.....	12,287,341	.00080	² 2,994
Kentucky.....	718,929	.00125	899
Louisiana:			
North.....	2,379,165	.00041	975
South.....	47,294,983	.00004	1,892
Michigan.....	1,768,581	.00156	2,759
Mississippi.....	1,410,514	.00049	691
Montana.....	991,668	.00081	² 899
Nebraska.....	72,839	.00066	48
New Mexico:			
Northwest.....	9,646,466	.00026	² 2,507
Southeast.....	3,615,023	.00039	1,410
New York.....	262,711	.00073	192
North Dakota.....	411,485	.00041	169
Ohio.....	1,560,478	.00134	2,091
Oklahoma.....	11,463,291	.00065	² 5,868
Pennsylvania.....	2,093,516	.00078	1,633
Texas:			
District 1.....	1,067,071	.00028	299
District 2.....	4,326,275	.00004	173
District 3.....	13,273,295	.00004	531
District 4.....	10,527,441	.00004	421
District 5.....	692,917	.00028	194
District 6.....	4,302,223	.00025	1,076
District 7B.....	860,879	.00142	1,222
District 7C.....	1,679,012	.00096	1,612
District 8.....	8,294,307	.00030	2,488
District 8A.....	1,075,564	.00067	721
District 9.....	990,496	.00118	1,169
District 10.....	7,510,755	.00103	² 4,431
Utah.....	698,655	.00029	173
Virginia.....	79,064	.00073	58
West Virginia.....	2,683,136	.00073	1,959
Wyoming.....	4,315,775	.00166	^{2,3} 15,523
Miscellaneous ⁴	258,984	NA	NA
Total.....	200,301,707	NAP	64,794

NA Not available. NAP Not applicable.

¹See appendix for definition.

²Natural gas reserves containing gases with helium contents of at least 0.3 percent subtracted from total natural gas reserves before average helium content applied.

³Includes 11,364 MMcf of helium in nondepleting gas reserves.

⁴Includes reserves of Arizona, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

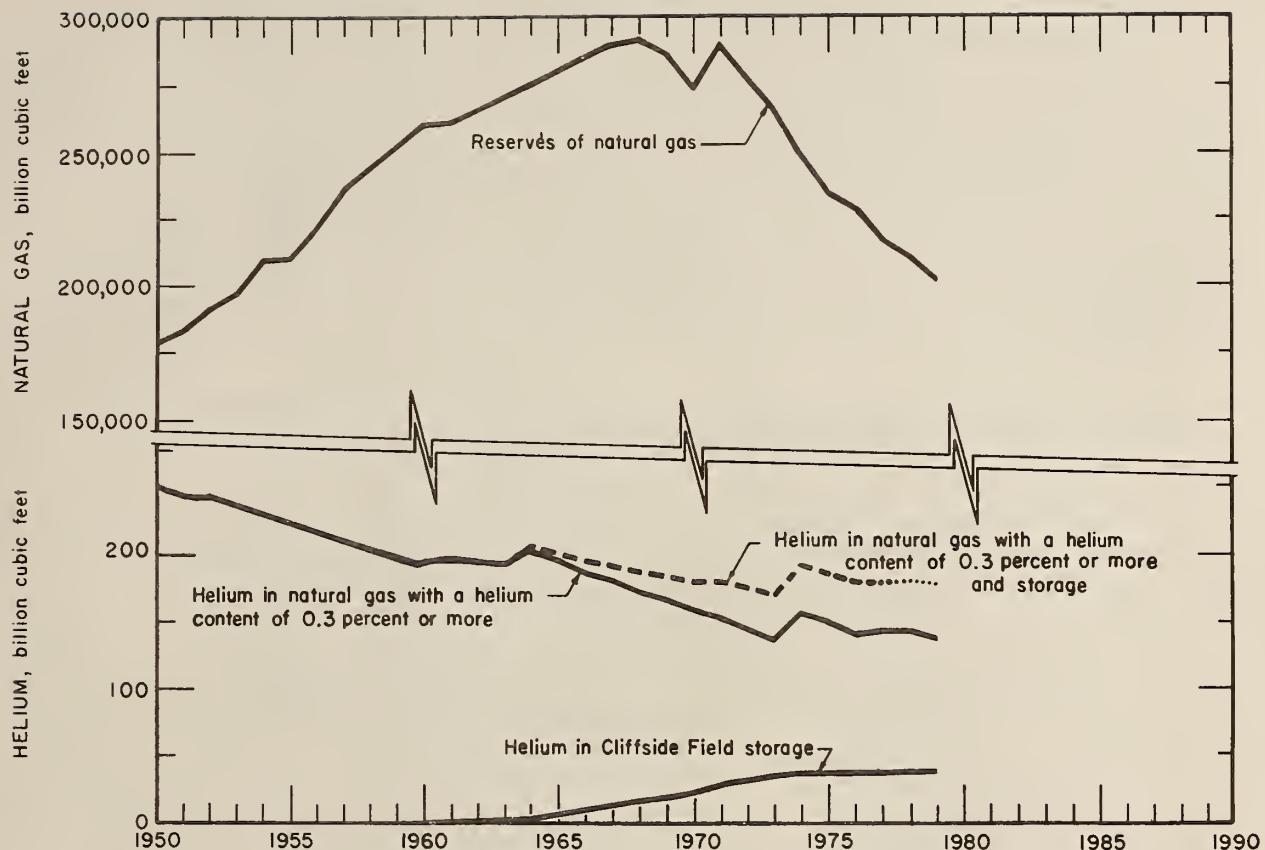


FIGURE 2. - Helium in natural gas containing 0.3 percent or more helium, helium in storage, and reserves of natural gas of the United States.

Data from the gas analyses files were used to determine the average helium content for gases having less than 0.3 percent helium in each AGA reporting area (table 3). These values were then applied to the estimated natural gas reserves to determine the volume of helium contained in gases with less than 0.3 percent helium. In areas having gas with 0.3 percent or more helium, the volume of gas was subtracted before the helium content was applied. In States previously mentioned, where fields containing 0.1 to 0.3 percent have been evaluated, the gas reserves and helium contents were adjusted in the same manner. The helium resources in measured gases with a helium content of less than 0.3 percent is estimated to be 64.8 billion cubic feet. A breakdown by geographical regions is given in table 3.

Helium in Potential Resources of Natural Gas

The PGC⁷ has estimated that there was 1,019 trillion cubic feet of natural gas in the Nation's potential natural gas resource base as of December 31, 1978.⁸ The potential resources of natural gas are broken down by the PGC in three categories, probable, possible, and speculative. These are listed in the order of likelihood of existence, with the probable category being associated with known fields, the possible category includes undiscovered fields in productive areas, and the speculative category resources are to be found in presently unexplored areas. The PGC defines these terms more specifically as follows:

- "a. Probable potential gas supply (associated with existing fields)
 - the most assured of new supplies.
- (1) Supply from known (previously discovered) accumulations obtained by:
 - (a) Future extensions of existing pools in known productive reservoirs.
 - (b) Future new pool discoveries, within existing fields, in reservoirs productive elsewhere within the same field.
- (2) Supply from new pool discoveries obtained by future shallower and/or deeper new pool discoveries, within existing fields, in formations productive elsewhere within the same geologic province or subprovince.
- b. Possible potential gas supply (associated with productive formations) - less assured supply. Supply from new field discoveries in formations productive elsewhere within the same geologic province or subprovince:
 - (a) Under similar geologic conditions,
 - (b) Under different geologic conditions.

⁷The PGC is sponsored by the Potential Gas Agency, Mineral Resources Institute, Colorado School of Mines, and is made up of representatives from the oil- and gas-producing industry, gas transmission industry, Government, and the academic community. The committee made its initial report on future natural gas supply in 1967, although a predecessor committee, the Future Gas Supply Committee, produced a report in 1964.

⁸Potential Gas Committee. Potential Supply of Natural Gas in the United States (as of December 31, 1978). Potential Gas Agency. Colorado School of Mines, Golden, Colo., 1979, 75 pp.

- c. Speculative potential gas supply (associated with nonproductive formations or nonproductive provinces) - the most nebulous of new supplies.
 - (1) Supply from new pool discoveries in formations not previously productive within a productive geologic province or subprovince.
 - (2) Supply from new field discoveries obtained by:
 - (a) Future new field discoveries in formations not previously productive within a productive geologic province or subprovince.
 - (b) Future new field discoveries within a geologic province not previously productive."

In comparing the PGC definitions with the terminology adopted by the Bureau of Mines and the Geological Survey, it appears that the PGC "probable" class is closely related to the Federal "indicated" category. This would then bring the "probable" resources into the "identified" range on the chart on figure 1. This is a seeming contradiction to the PGC's treatment of that class of reserves; however, it seems to be the best placement. A Geological Survey report discusses the PGC estimates,⁹ stating (p.19) that the "probable" category includes, however, some known resources, in the sense of having been discovered but not completely developed, and some unknown resources, so that the category brackets the boundary between the known and the unknown." For this report and the previous Bureau studies, the PGC "probable" category will be compared with the "indicated" group under "identified" resources, and PGC's "possible" and "speculative" will be compared with "hypothetical" and "speculative" in the undiscovered category in Bureau of Mines terminology.

The helium contained in the potential gas resources as evaluated by the PGC was estimated by using the average helium contents shown in table 3 for the natural gas resources for each of the PGC areas outlined on figure 3. These average helium contents were again derived from the results of the Bureau's evaluation of helium occurrences and gas analyses. Helium contained in these potential gas resources is estimated to be 482.0 billion cubic feet. In addition, the Bureau estimates that there is 60.1 billion cubic feet of helium in indicated resources of known fields containing nondepleting gas. The total helium resources then, in the indicated, hypothetical, and speculative categories, is 542.1 billion cubic feet.

⁹Theobald, P. K., S. P. Schweinfurth, and D. C. Duncan. Energy Resources of the United States. U.S. Geol. Survey Circ. 650, 1972, 27 pp.



FIGURE 3. - Potential Gas Committee map.

The range of helium contents for the various PGC areas is from 0.004 to 0.146 percent. Table 4 shows the estimates of the natural gas resources for all areas of the United States and in the various categories as designated by the PGC. Table 5 shows the helium content estimated for each PGC area and the volume of helium estimated to be contained in the natural gas resources shown in table 4. It was assumed that the helium content of the gas discovered in the future would be the same as past discoveries in all PGC areas except Area J North, which includes the Texas Panhandle, Oklahoma, and Kansas. This area contains about 70 billion cubic feet of the helium in proved or measured gas reserves having at least 0.3 percent helium. Since it is not deemed likely that gasfields with more than 0.3 percent helium of the size of Hugoton or West Panhandle will be discovered in the future, it seemed prudent to discount these large reservoirs when considering the helium content of future discoveries. As a result, the weighted average helium content of the natural gas streams having 0.29 percent or less that were leaving Area J North was used for the potential or undiscovered gas resources.

TABLE 4. - Potential Gas Committee estimate of potential supply of natural gas in the United States as of December 31, 1978, by geographical area

(Trillion cubic feet at 14.73 psia and 60° F)

Area	Probable	Possible	Speculative	Total
A.....	26	9	86	121
B.....	6	7	40	53
C.....	0	3	1	4
D.....	8	20	22	50
E.....	38	60	0	98
G.....	36	45	4	85
H.....	23	80	57	160
I.....	2	3	1	6
J North.....	28	70	45	143
J South.....	16	36	1	53
K.....	13	40	136	189
L.....	3	26	28	57
Total.....	199	399	421	1,019

TABLE 5. - Estimated helium in potential supplies of natural gas as of December 31, 1978, by Potential Gas Committee area

(Volumes in billion cubic feet at 14.73 psia and 60° F)

Area	Helium content fraction	Indicated helium in probable gas	Hypothetical helium in possible gas	Speculative helium in speculative gas	Total helium
A.....	0.00092	23.88	8.24	79.15	111.27
B.....	.00049	2.92	3.41	3.41	9.74
C.....	.00146	.00	4.36	1.45	5.81
D.....	.00057	4.54	11.40	12.53	28.47
E.....	.00004	1.52	2.40	.00	3.92
G.....	.00005	1.80	2.25	.20	4.25
H.....	.00065	¹ 63.10	51.98	37.04	152.12
I.....	.00029	² 12.19	.87	.29	13.35
J North...	.00113	31.70	79.12	50.80	161.62
J South...	.00042	6.72	15.08	.42	22.22
K.....	.00014	1.82	5.60	19.04	26.46
L.....	.00005	.15	1.30	1.40	2.85
Total...	NAp	150.34	186.01	205.73	542.08

NAp Not applicable.

¹ Includes 48.17 Bcf helium in nondepleting resources.

² Includes 11.62 Bcf helium in nondepleting resources.

NATURAL GAS DISCOVERY RATES

Each year, as the AGA makes estimates of the natural gas reserves of the Nation, it compiles data on the volume of natural gas discovered and publishes that information along with natural gas reserve data. Table 6 gives the estimates of the volume of natural gas discovered each year from 1946 through 1978. Through 1967, the additions to reserves were greater each year than the volume of gas produced, thus the reserves continued to increase. However, in 1968, that trend was reversed, and since that time, production had exceeded additions every year except 1970, when the gas reserves on Alaska's North Slope were added. This has resulted in a steadily declining natural gas reserve in the United States.

TABLE 6. - Additions to the proved natural gas reserve of the United States as estimated by the American Gas Association

(Million cubic feet at 14.73 psia and 60° F)

Year	Additions	Year	Additions	Year	Additions
1946	17,632,864	1957	20,008,055	1968	13,697,008
1947	10,921,187	1958	18,896,718	1969	8,375,004
1948	13,823,090	1959	20,621,252	1970	¹ 37,196,359
1949	12,605,464	1960	13,893,979	1971	9,825,421
1950	11,984,290	1961	17,166,422	1972	9,634,563
1951	15,965,808	1962	19,483,959	1973	8,825,049
1952	14,267,602	1963	18,164,667	1974	8,679,184
1953	20,341,936	1964	20,252,138	1975	10,483,688
1954	9,547,070	1965	21,319,279	1976	7,555,468
1955	21,897,619	1966	20,220,432	1977	11,851,924
1956	24,716,114	1967	21,804,333	1978	10,586,144

¹Alaskan reserves added.

Natural gas discovery rates are dependent on many factors. Among these are the availability of drilling prospects, price of gas and oil, regulatory climate, economic climate, supply-demand situations, and economic incentives. Except for 1970, when the North Slope reserves were added, discovery rates have dropped from an average of 18 to 20 trillion cubic feet for 1955-67 to less than 10 trillion cubic feet for 1968-78.

Figure 4 shows the cumulative additions to the natural gas reserves for 1946-78. A least-squares fit of several segments of the plot was made, and the lines were extrapolated based on the segments for the periods 1946-78, 1950-78, 1960-78, and 1970-78.

Of course, with each extrapolation being a least-squares fit of the data, the results are straight line projections, but in reality, the discovery rate is likely to decline as the limit of total resource is approached. However, for the period of concern for this report, the discovery rates appear reasonable.

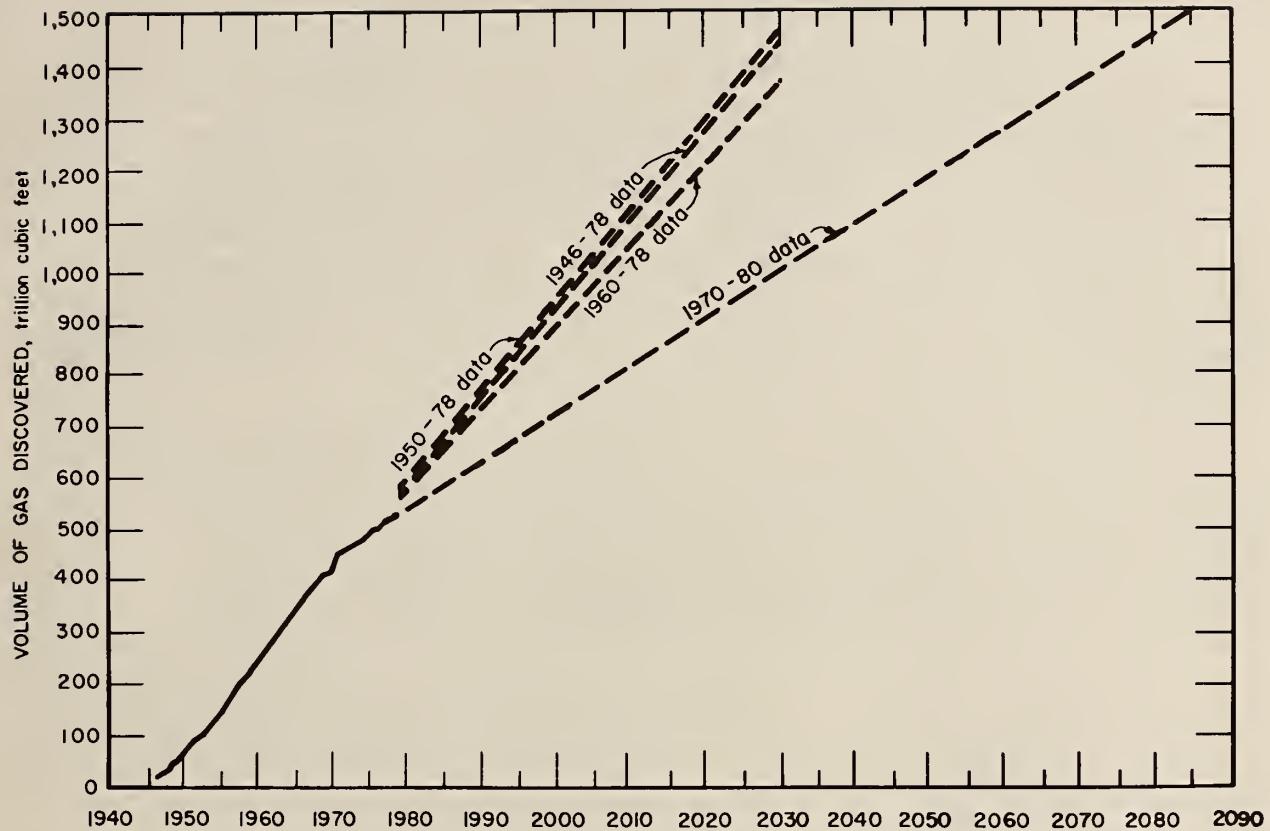


FIGURE 4. - Cumulative additions to American Gas Association's estimated reserves and extrapolation of segments of these additions.

The projections for the first three segments are grouped very closely, with annual discoveries ranging from 16 to 18 trillion cubic feet. If the natural gas resources are found at these rates, the 1,019 trillion cubic feet estimated to exist by the PGC will be discovered by about 2040. The projection of the line based on additions to reserves for 1970-78 shows discoveries at only about 9 trillion cubic feet per year, only about half the discovery rate for the other three periods. This rate of discovery would extend the time required to find all of the natural gas resources to about 2090.

It appears that even with the lowest annual discovery rate of 9 trillion cubic feet per year, the United States will be able to produce the quantities of gas that are forecasted to be available in the next section of this report. However, this would cause a continued drawdown of the Nation's natural gas inventory. This drawdown began in 1968 when production first exceeded additions.

DISSIPATION OF HELIUM RESOURCES

In past reports in this series, gas production forecasts were made by using data published by the Gas Requirements Committee (GRC), or as it was formerly known as the Future Requirements Committee (FRC), and extrapolating those data to cover the desired time period. In 1979, because of the change of location of the Gas Requirements Agency which oversees the work of the GRC, the new report of the GRC was not due until the early part of 1980, thus forecasts on future natural gas production for this report are based on data developed by the AGA. These gas production forecasts were made through 2000, and these data were shown in the draft report by the AGA's Gas Supply Committee.¹⁰ The forecasts appearing in that report have been extrapolated to 2020 for the purposes of this publication.

The AGA used gas data from the Department of Energy's National Energy Plan II estimates for the contiguous 48 States to develop their forecast. Separate studies were made for gas from Alaska. The gas from Alaska's North Slope has not yet been put on production even though the gas reserves were added to the AGA estimate in 1970. A pipeline is expected to be constructed to carry the gas through Canada to the lower 48 States, and production is expected to be started in 1985. By 2000, production is forecasted to reach 3.0 trillion cubic feet per year from the North Slope. The extended period from discovery to production of the North Slope gas reserves points out one of the characteristics of the gas industry, although this is an exaggerated case. It does indicate that there is a certain amount of lead time required from discovery of gas reserves to the time that those reserves are put on production.

The AGA forecast of gas production is shown on table 7. To forecast available helium in natural gas produced for market, the average helium content for each area was applied to those forecasted gas production rates. Since the AGA forecasts were made only through 2000, it was necessary to extend these through 2020 for the purposes of this report. The extension was based on past production (shown on figure 5), the AGA forecast through 2000, the volume of proved reserves, and the undiscovered gas resources estimated by the PGC. The forecasted natural gas volumes and the helium expected to be produced with the gas are shown in table 8 and on figures 6-7.

¹⁰American Gas Association, Gas Supply Committee. Workshop on Natural Gas Gas Supply Forecasts, Houston, May 24, 1979. 72 pp.

TABLE 7. - Potential United States gas supplies through 2000¹

(Trillion cubic feet at 14.73 psia and 60° F)

Source	Year					
	1978 Actual	1980	1985	1990	1995	2000
NEP II conventional (lower 48) ² ...	19.1	18-19	16-18	15-17	13.5-15.5	12-14
Potential supplements:						
Canadian.....	.9	1.4	1.4	1.1	1.0	.8
SNG.....	.3	.5	.5	.5	.5	.5
LNG imports.....	.1	.4	1.6	2.0	2.5	3.0
Mexican gas.....	-	.2	.5	1.0	1.0	1.0
Alaskan gas:						
Southern.....	-	-	.1	.2	.3	.6
North Slope.....	-	-	.7	1.4	2.2	3.0
Coal gasification.....	-	-	.1	.6	1.8	3.3
New technologies.....	-	-	.9	1.8	3.2	5.0
Subtotal supplements.....	1.3	2.5	5.8	8.6	12.5	17.2
Total.....	20.4	20.5-	21.8-	23.6-	26.0-	29.2-
		21.5	23.8	25.6	28.0	31.2

NEP II National Energy Plan II.

SNG Synthetic natural gas.

LNG Liquefied natural gas.

¹Table taken from "Report on the Gas Supply Committee - Workshop on Natural Gas Forecasts, Houston, May 24, 1979."²Years 1985 and 2000 from NEP-II, intervening years (1980, 1990, 1995) by interpolation.TABLE 8. - Total natural gas and contained helium estimated to be produced in the United States

(Billion cubic feet at 14.73 psia and 60° F)

Year	Natural gas production	Contained helium	Year	Natural gas production	Contained helium
1979.....	18,915	12.78	2000.....	16,719	7.38
1980.....	18,567	12.11	2001.....	16,388	7.36
1981.....	18,323	11.59	2002.....	16,080	7.01
1982.....	18,027	11.10	2003.....	15,783	6.83
1983.....	17,685	10.64	2004.....	15,416	6.63
1984.....	17,459	10.29	2005.....	15,233	6.40
1985.....	17,904	10.02	2006.....	14,960	6.09
1986.....	17,898	9.77	2007.....	14,752	5.97
1987.....	17,812	9.52	2008.....	14,397	5.79
1988.....	17,828	9.33	2009.....	14,077	5.66
1989.....	17,727	9.13	2010.....	13,839	5.50
1990.....	17,700	8.94	2011.....	13,515	5.37
1991.....	17,635	8.75	2012.....	13,148	5.20
1992.....	17,413	8.57	2013.....	12,865	5.11
1993.....	17,350	8.41	2014.....	12,652	4.97
1994.....	17,257	8.24	2015.....	12,330	4.83
1995.....	17,118	8.08	2016.....	12,014	4.67
1996.....	17,014	7.85	2017.....	11,679	4.52
1997.....	16,875	7.76	2018.....	11,415	4.37
1998.....	16,759	7.62	2019.....	11,217	4.22
1999.....	16,676	7.57	2020.....	10,820	4.07

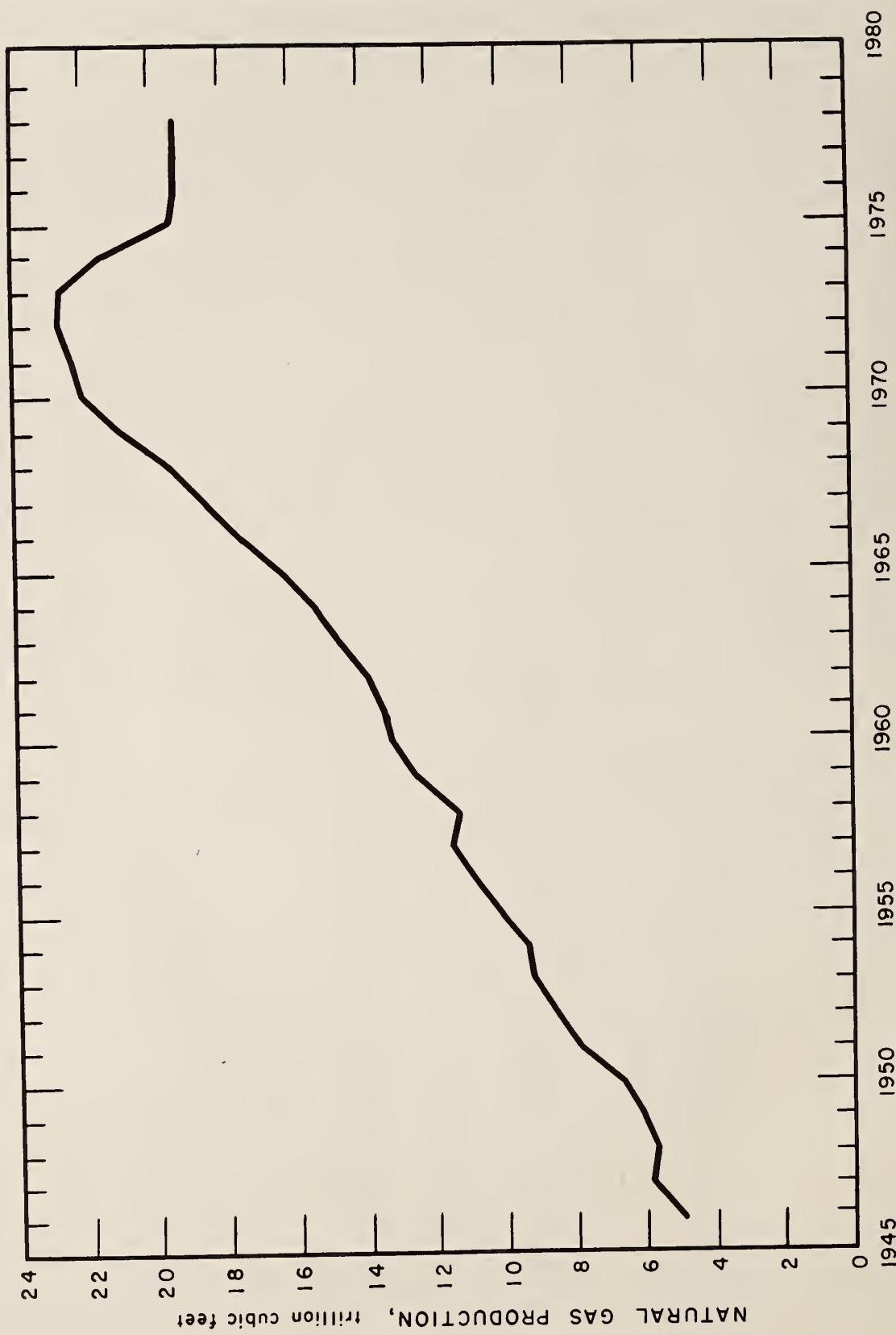


FIGURE 5. - American Gas Association annual gas production estimates.

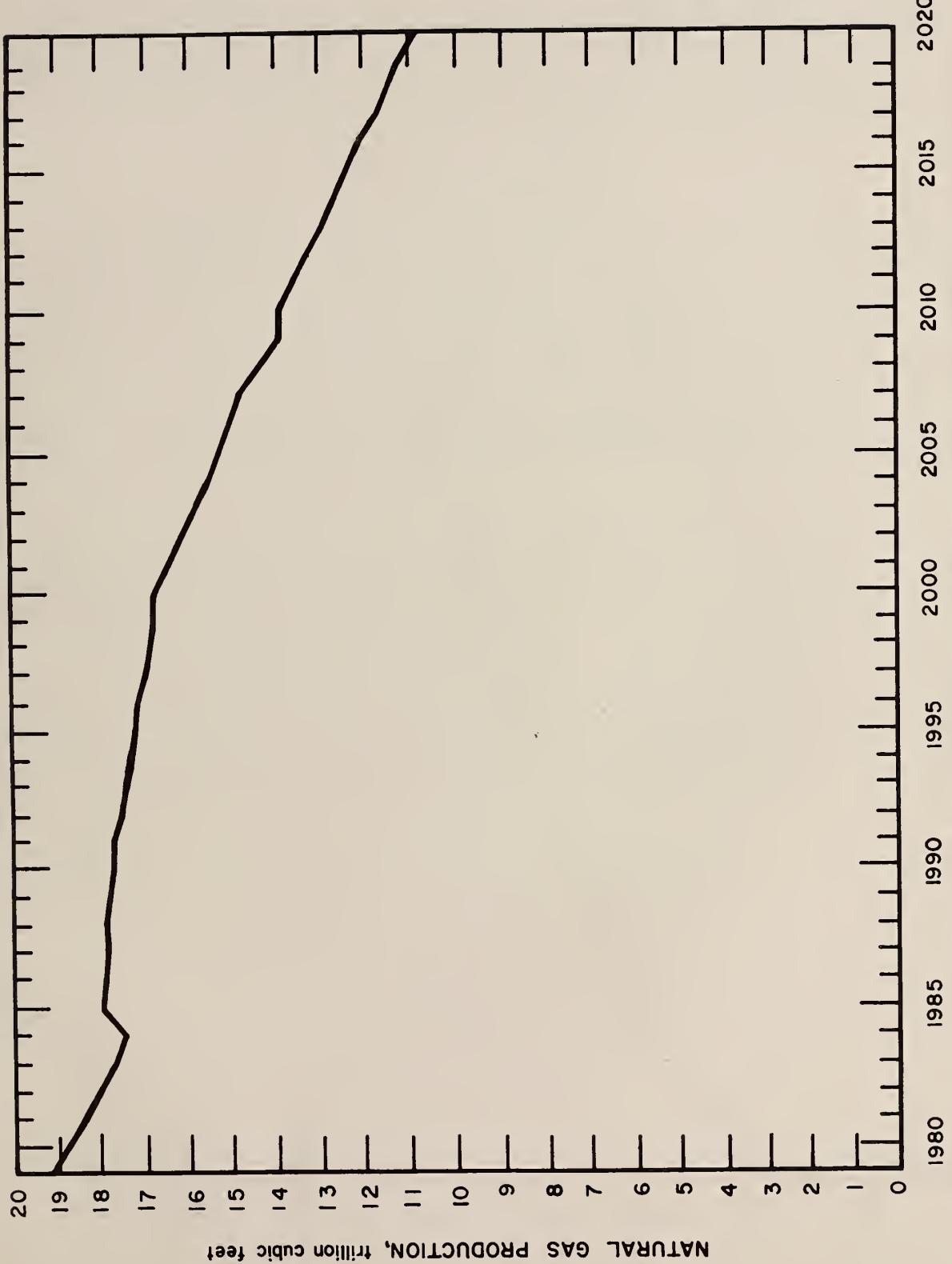


FIGURE 6. - Projected natural gas production in the United States.

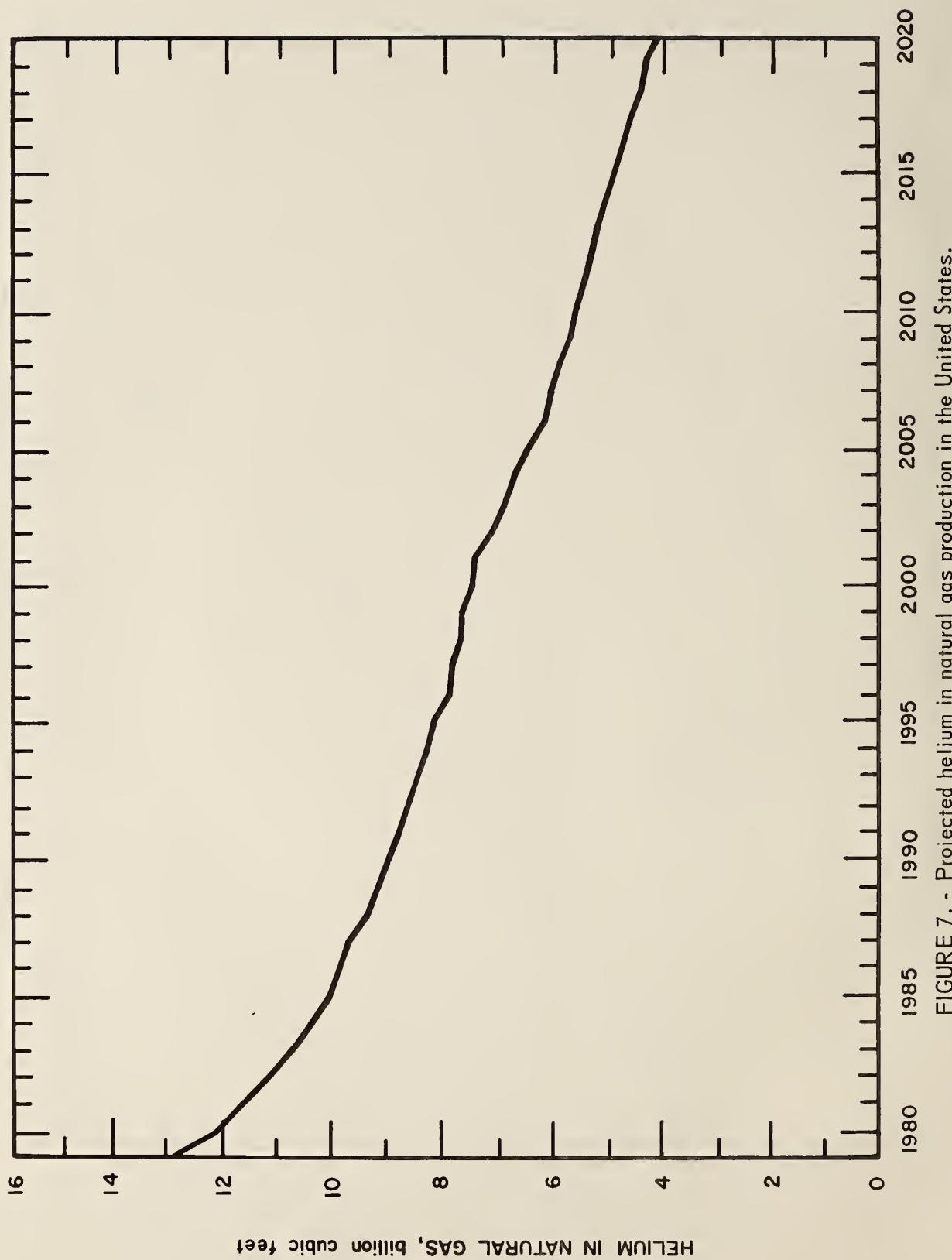


FIGURE 7. - Projected helium in natural gas production in the United States.

Some of the demand for natural gas in future years is expected to be filled by imports, synthetic natural gas (SNG), or imported liquefied natural gas (LNG). The expected volumes from these sources are also shown on table 7. It must be emphasized again that discovery rates and production rates depend on many variables. Unless proper conditions exist, much of the demand may go unfulfilled and much of the potential gas resource may remain undiscovered.

CONCLUDING STATEMENT

In the previous report in this series, it was concluded that relatively large volumes of helium would be available from natural gas through 2020, although the helium would probably be in gases with leaner concentrations than that being processed today. There have been no developments in the past 2 years to alter these conclusions and the PGC estimates of undiscovered natural gas resources have increased adding support to this belief. Because of the expected leaner concentrations of helium in natural gas, extraction plants will have to process larger quantities of gas to recover equivalent volumes of helium. This will probably require the extraction plants be located on gas transmission systems that bring large volumes of natural gas together at one point.

As of January 1, 1979, there was 39.1 billion cubic feet of helium in storage in Cliffside field. The Bureau of Mines owns 35.6 billion cubic feet, 1.5 billion cubic feet was accepted under court order and its ownership is under litigation, and 2.0 billion cubic feet is owned by private companies and is stored under separate storage contracts. There is also about 4.0 billion cubic feet of helium contained in the native gas in Cliffside field and the gas is owned by the Bureau. This reserve of helium, plus the helium under contract to the Bureau in Keyes field where the Government is extracting the helium, and the helium on Federal lands in presently nondepleting fields will fill the Bureau's mission of supplying helium to meet all essential Government needs for many years beyond 2000.

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APPENDIX.--GLOSSARY¹

Helium Resource.--All helium contained in natural gases and helium that has been extracted from natural gases and is being stored for future use.

Helium Reserve.--The portion of the identified helium resource that is in storage and the helium contained in the measured and indicated resources of gases containing at least 0.3 percent helium. These are the resources now being processed for helium or those most likely to be processed if helium demand is increased.

Helium in Storage.--The helium stored by the Federal Government in Cliffside field.

Identified Resource.--A collective term for the sum of materials in both measured and indicated resources.

Measured*.--Helium in gas reserves for which estimates have been made with a margin of error of less than 20 percent.

Measured resources are comparable to those reserves termed "proved" by the gas industry.

Indicated*.--Helium in gas resources associated with measured reserves for which estimates have been made by using reasonable engineering and geologic projections.

Indicated resources are comparable to those resources termed "probable" by the gas industry.

Undiscovered Resources.--Unspecified deposits of helium surmised to exist on the basis of broad geologic knowledge and theory.

Hypothetical Resources*.--Undiscovered helium that may reasonably be expected to exist in a known gas-producing area under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as an identified resource.

Hypothetical resources are comparable to those resources termed "possible" by the gas industry.

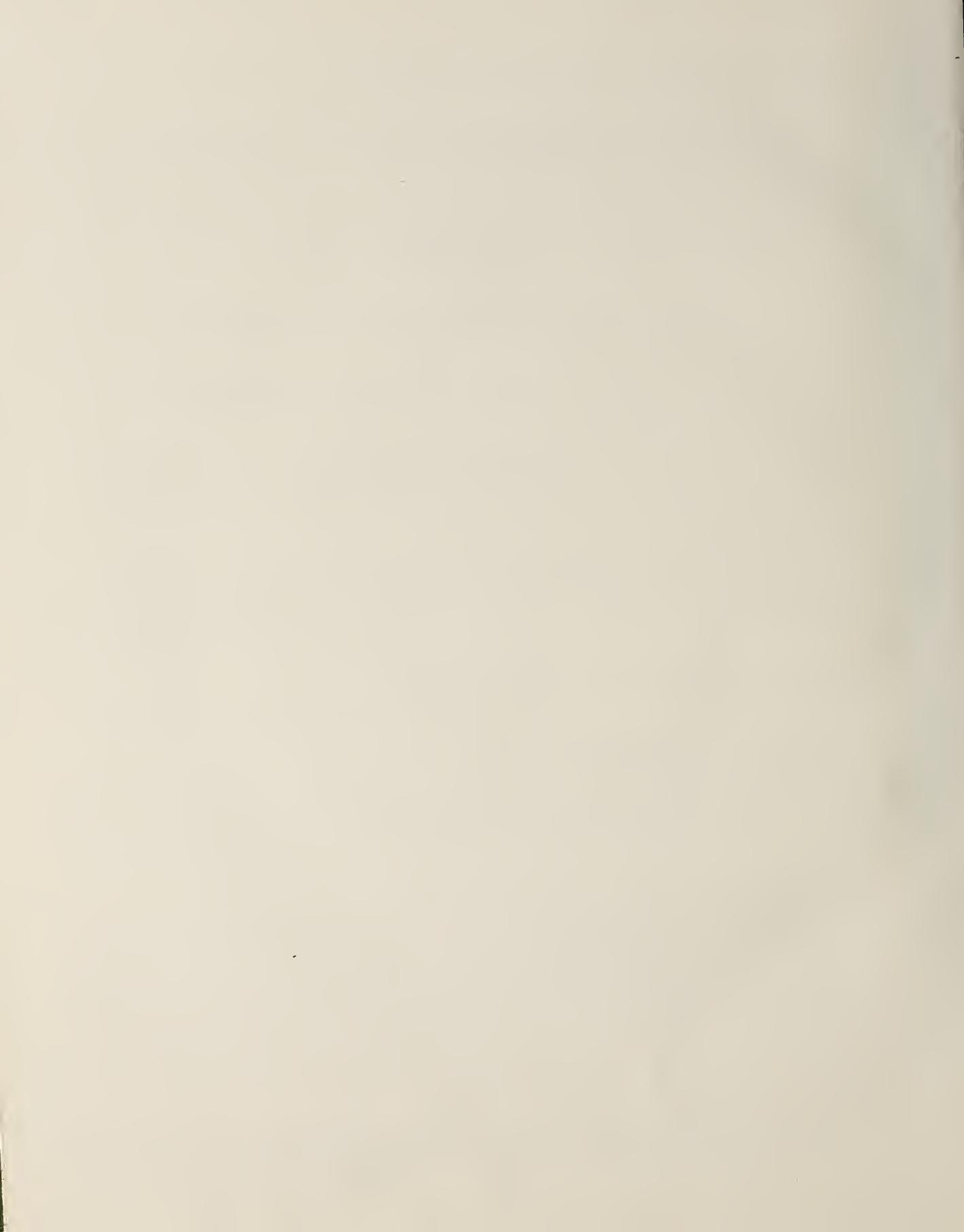
Speculative Resources*.--Undiscovered helium deposits that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification.

Speculative resources are comparable to those resources also termed as speculative by the gas industry.

¹Asterisk (*) beside a term indicates that there is a comparable gas industry term; these terms are explained at the end of the entry.

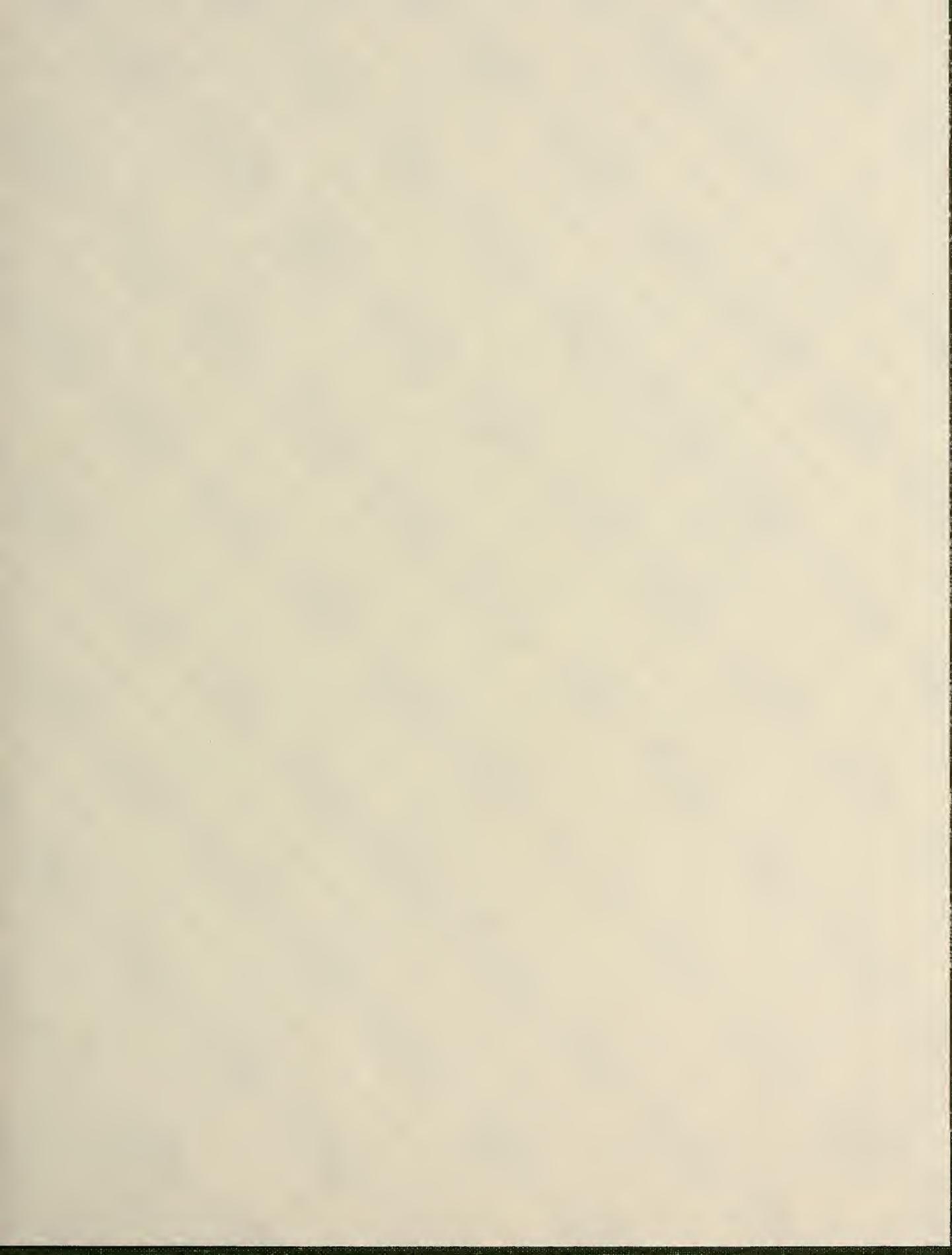
Depleting Natural Gas Resource.--A natural gas deposit that is being depleted by production for use as fuel or other purposes.

Nondepleting Natural Gas Resource.--A natural gas deposit that is not being produced because of the low heating value of the gas, lack of market, or some other reason.

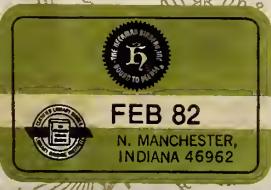




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